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POPULAR MECHANICS

An Illustrated Weekly Review of the Mechanical Press of the World

"Tells you how to do things." Written so you can understand it.

Vol. 2. No. 12. CHICAGO, SEPTEMBER 20, 1902. PRICE 5 CENTS.

DRILLING THE GREAT SUBWAY UNDER NEW YORK

Night and Day the Work Goes On Unceasingly

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Longest Telephone Span in the World.
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Shop Notes:—Stopping Leaks in Steam Mains—Fitting Connecting Rod Brasses—Protecting Ends of Shafting—A Fool Experience—Judging Quality of Solder—Bolting Cloth Pinchers—Spring Dividers for Small Circles—Comparing Weight of Water—When Oil Fuel is Economical.

Popular Mechanics can be bought of any newsdealer in the United States.

DIGGING THROUGH ROCKS UNDER NEW YORK'S STREETS.

Compressed Air Machinery Made Possible the Rapid Transit Tunnel, Which Is One of the Greatest Undertakings in History.

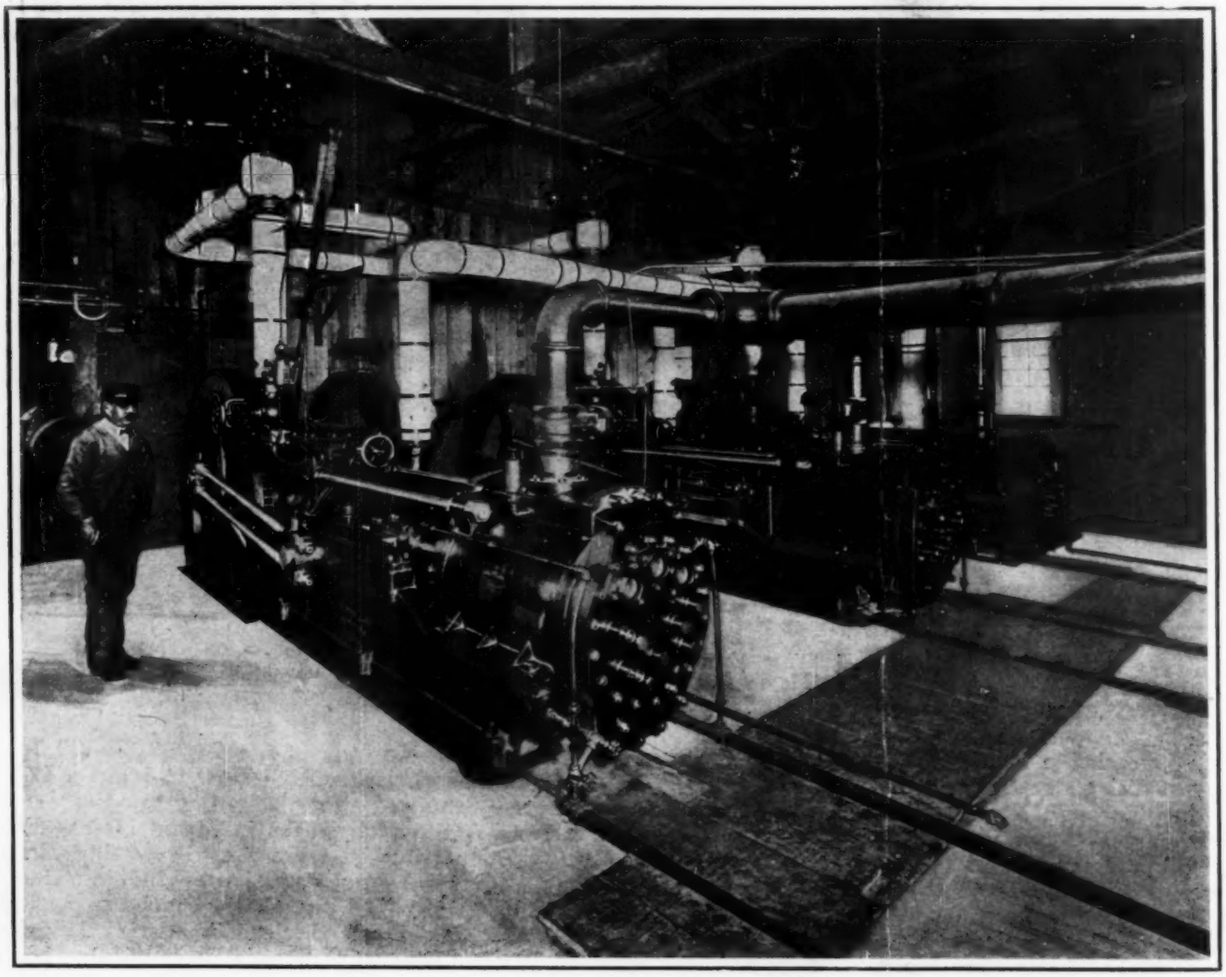
While the great swarm of people, thundering cars and rumbling cabs are sweeping through the streets of New York, under the ground beneath their feet men are busy with drills and shovels digging a tunnel that is to be the engineering marvel of the age. This tunnel was a necessity to New York. With its rapidly increasing population and growing congestion of traffic there was no other alternative than to relieve the cramped conditions by providing a passageway for traffic under the street. It was a mammoth undertaking. Long it had been known that such a system of subterranean ways should be built, but how to build it was the question.

The topography of New York is queer. Sky-reaching buildings lined the route the tunnel should pursue; the underground was a net of beams, wires, vaults, sewers, pipes and irons of all descriptions; street railway tracks and elevated roads stretched along the streets. These obstacles, it was found, could be overcome; but the granite-like rock on which a large part of the city was built seemed prohibitory to a subway. The original layers of rock are disturbed and distorted and many of them much inclined. In fact, most of the beds are more nearly vertical than horizontal. Sometimes in a small space layers are doubled on themselves. Seldom can the rock here be broken into pieces of regular size and thickness. Some parts are often soft and decomposed and the others hard as granite. Many seams occur which are sometimes filled with decomposed mica or clay and sometimes serpentine and talc. These seams when unsuspected cause dangerous slips, as on Park avenue, where the foundations of some of the houses were threatened.

Thus it was early seen that the digging of a hole large enough for traffic through this treacherous rock was a difficulty of threatening proportions. The greatest engineers of the world were called on in its solution.

Compressed air solved the problem. Without the compressed air rock drill the great tunnel would never have been undertaken. It was remembered that it was compressed air machinery that made possible the digging of the Chicago Sanitary and Ship Canal, and so it was decided that the compressor plant should be employed in digging the tunnel. With it the work was easy. It was found to be admirably adapted to the modern riveting machine, the rock-drill pumps, hoisters and other machinery. The Rand drills and Rand air compressors in centralized air power plants were put in operation and the digging of the way through the miles of rock underneath New York has progressed without interruption since. It would have taken a century to have dug through this vast amount of rock formation with hand drills and the cost would have been fabulous.

The tunnel is being built in sections or divisions in order to enable as large a number of men and machines as possible to work at the same time. Night and day the work progresses without interruption. The operation of the drills is simple. At intervals there have been established compressing plants. Here powerful steam engines pump air into strong steel tanks until the



One of the Rand Compressor Plants.

At Work Under Broadway at 181st Street.

pressure in the tank reaches 200 pounds. To the observer these engines and air pumps look very much like the engines and pumps used in water works of smaller cities. From the storage tank iron pipes lead to the several points where the drilling is being done. A strong rubber hose leads the air from the distributing pipe to each drill. The drill is set up on three legs like a camera on a tripod. The drill is in reality a small vertical engine, the lower end of the piston rod having a clamp into which the drill rod is fastened. When air is let into the machine the drill darts back and forth with great rapidity, and at each blow the drill point is turned slightly. The drill points are shaped something like a chisel. Occasionally the operator turns a wheel, which lowers the drill farther into the hole as the work progresses. The compressed air exhausts from the machine at each stroke. When the required drilling is completed the drills are removed to a safe distance and the firing crew appear, fill the holes with explosives and fire the blasts, after which more holes are drilled, and so the work goes on unceasingly.

The total length of track to be built will be about 58 miles. Of this amount more than three-fourths will be underground and the rest elevated. There will be about 3,212,000 cubic yards of material to be excavated—1,900,000 cubic yards of earth, 884,000 cubic yards of rock in open cut, and 428,000 cubic yards of rock tunneling. This excavation will require about two-thirds of the time allotted for completing the subway. In the construction there will be used 65,000 tons of steel, 8,000 tons of cast iron, 551,000 cubic yards of concrete and 910,000 square yards of water-proofing. Underneath the more congested districts the tunnel will contain four tracks. From 150th street to 190th street the subway will be dug through solid rock and will have a regulation double track with concrete arch. This one section of the tunnel, if not lost sight of in the magnitude of the huge system of tunnels, would in itself be regarded as a great feat of engineering. At 169th and 181st streets stations are being hollowed out of the solid rock at a depth of 110 feet below the street level. These stations will be provided with passenger elevators to take the passengers from the street to the underground cars. The elevators will occupy the space now being used as material shafts in which the lifts of the contractors operate.

The contract to build the New York subway was let in January, 1900, to John B. McDonald, to be completed in four and a half years. The price was $35,000,000. This was the largest single contract ever let and it was for the most comprehensive system of rapid transit ever devised.

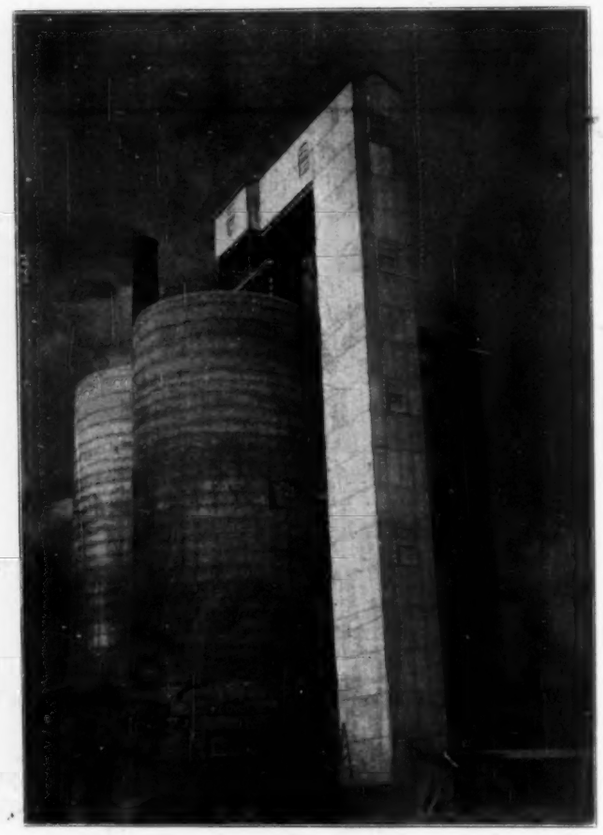
NO EVES, BUT SEVEN HUNDRED ADAMS IN CHICAGO.

In the Chicago city directory there are 700 Adams and not a single Eve. Of Cains there are 55 and Abels 8. The city is well supplied with patriarchs—100 Abrahams, 19 Isaacs and 600 Jacobs; and of Solomons there are 110. There are 15 Darlings, but two men whose name is Kill, and there is a total of 90 Loves, but not a Lover, although there is one Mormon. It seems that, after all, the men in Chicago are divided in about the same proportion as the men of the world, according to New Testament inferences. There are 25 Hopes, 7 Faiths, and one poor, lone Charity among the names. There are 8 Pains and only one Well.

MOST REMARKABLE STORAGE ELEVATOR EVER BUILT.

Constructed Entirely of Concrete, Wire Mesh and Iron—Used for Storage of Cement.

A storage elevator, unlike any other ever built, and by many regarded as the most remarkable in the world, has been erected for the Illinois Steel Company in South Chicago. The elevator is built entirely of concrete, woven wire and metal plates. It is used for the storage of cement, which is brought from an adjoining



Monier Concrete Storage Elevator.

mill by means of a screw conveyor. The elevator consists of four circular Monier concrete tanks, each 25 feet in diameter and 50 feet high. The intermediate space, formed by placing the four circular tanks in a cluster, is also used for storage. The bottom of the storage portion of each tank is elevated 15 feet above the ground and is supported upon Monier columns consisting of steel rails imbedded in concrete. These column rails extend 2 feet into the foundation and rest upon steel plates 1 inch thick. The foundation is of a layer of concrete 3 feet thick near the under side, of which there is a Monier netting of ⅝-inch steel rods laid to 9 inches center, with the intersections wired together with No. 18 annealed wire.

The Railway Review says: "The walls of the tanks are 7 inches thick at the bottom and 5 inches thick at the top, and consist of a skeleton of No. 9 wires electrically welded together in a fabric of 1x4 inch mesh, to which annular rods are fastened 4 inches apart by means of No. 18 annealed wire; around the skeleton the concrete is molded in proper forms. At the bottom the diameter of the rods is 1 inch, the size gradually decreasing toward the top, where the diameter is ⅜ inches."

The Cement and Engineering News, the recognized American authority on such topics, says that the structure is of wonderful stability and admirably adapted to the uses for which it was designed.

The tower is built of a skeleton of steel angle bars, covered with plates ⅝ inch thick, 2 feet wide and 5 feet long, interlocked so as to be watertight.

The work was planned and supervised by E. Lee Heidenreich, 541 Rookery Building, Chicago.

LONGEST TELEPHONE SPAN IN THE WORLD.

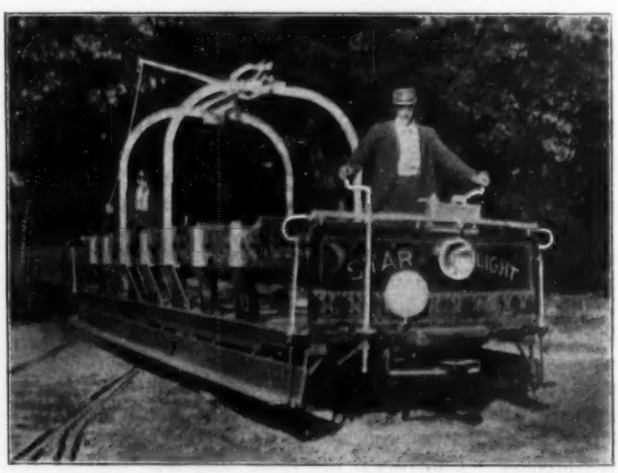
Across the Susquehanna river, connecting the telephone system of Lancaster and York counties, Pa., has been swung the longest aerial telephone cable span in the world. The work was done under the supervision of H. C. Young, president and general manager of the Columbia Telephone Company, at Columbia, Pa. The line crosses from Chickie's Rock to "The Point," an air-line distance of 3,200 feet. The wire dips to within 35 feet of the water surface, or 122 feet below a straight line between the poles Owing to the swift current, rocky bottom and ice gorges, the laying of a submarine cable was impossible, and the suspended cable was the only means of connecting the two telephone exchanges.

AN ATHLETE AT 106.

Capt. Goddard E. D. Diamond, of San Francisco, is an athlete at the age of 106. He has never been married. He spent his early life in a wilderness of Maine, helping to till the soil and fell the trees. This early association with nature he regards as the foundation for his lifelong health. When he was 19 years old he went to Boston and there learned to read and write. Thus, he says, in his maturing years he escaped the poisonous air of the school-room. During the war he was appointed chief government agent in the quartermaster and commissary department at St. Louis. He served through the war, enduring many hardships, and has lived all over the United States. The captain has since his fiftieth year avoided meats and selected foods that contained the least waste and greatest amount of nutriment.

STREET CARS WITHOUT ROOFS.

Street cars without any roofs may be seen in Augusta, Ga., says the Street Railway Review. The cars are used for private excursion parties and are chartered for their exclusive use. The fittings and trimmings are handsomely done in silver and gold, and brilliantly illuminated with electric lights. The car will hold about forty people, and with an orchestra furnishes a delightful ride about the city on pleasant evenings. Other cities will probably adopt the same system.

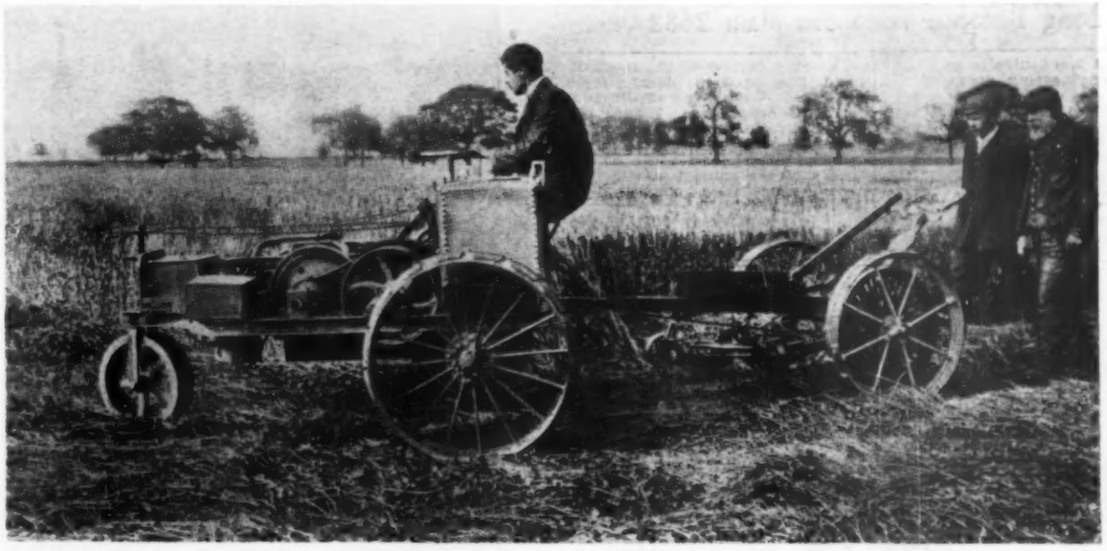


Roofless Cars in Augusta.

HORSELESS FARM IMPLEMENTS HAVE COME.

Life of the Agriculturist Changed by the Introduction of Motor Mowers, Reapers and Plows.

Automobile mowers and reapers have now made their appearance, and the auto-plow is on its way. These machines, which are said to be much more economical than horse power, will probably mark a new era in farm cultivation. The up-to-date



The Ivel Agricultural Motor in Operation.

farmer will sit in his easy seat on his motor and as he speeds through the fields his grain will be harvested in half the time it was before, far more conveniently and at a less expense. The agricultural motor, shown in the accompanying illustration, is the invention of Daniel Albone, an English manufacturer. The Motor Age in describing the device says:

"The Ivel agricultural motor is of the portable type and constructed to draw mowers, reapers and other agricultural machines. Apart from its full use, chaff cutting, root pulping and corn grinding are well within its province. The motor is of 8 horse-power, double cylinder, water cooled. It has electric ignition, one speed forward and reverse, and the inventor claims that any intelligent man can drive it after a short tuition. The engine is free, and when put in motion a friction clutch is employed to transmit the power through an intermediate shaft to the balance gear shaft of road wheels by means of patent silent chains. The wheels have extra wide rims with grip to prevent them from skidding around. For traveling on the high road detachable rubber pads are attached to the rims of the wheels by means of thumb screws. The cost of fuel in running the Ivel motor is considerably less than the cost of keeping horses."

LIGHTNING NEVER STRIKES THE SEA.

From experiments recently conducted by Prof. John Trowbridge of Harvard it is pretty clearly demonstrated that lightning never strikes the surface of the ocean. He experimented with electric sparks 6 feet in length with a view of voltalizing water for the purpose of obtaining a strong spectrum of water vapor. He found that his sparks, of high electric motive force, and as far as possible resembling lightning, always refused to strike the surface of the water and passed, instead, to the edge of the vessel containing it. He also found it extremely difficult to pass powerful sparks from one stream of water to another. One interesting conclusion which the professor draws, is that "it does not seem probable that lightning discharges pass through regions in the air of heavy rainfall."

BRITISH SHIPBUILDING SUFFERS.

England No Longer Has the Lucrative Monopoly It Once Enjoyed.

British class journals are greatly agitated over the growing depression in England's shipbuilding. With the freight market in its present wretched state there is little inducement to build new vessels, and reports from the British shipbuilding centers show an alarming diminution of new contracts. Norway has just wrested the orders for two American mail boats from the British bidders. Germany, not content with supplying the growing home needs, is now building vessels for the Danish and Russian owners, who formerly took all their contracts to England. The Shipbuilding Gazette of London says that the truth, which needs to be recognized, is that in the methods of production which make for economy England is behind America, and in scientifically trained workmen is behind Germany.

STEEL RAILROADS FOR WAGONS IN NEW YORK.

Steel railroads for wagons are to be given a practical test in New York. It is contended by many that they are as much of a necessity for wagon traffic in cities as are rails for trolley cars. The movement is backed by the Automobile Club of America and has the hearty co-operation of the United States Steel corporation and the city authorities. President Schwab of the steel corporation has agreed to furnish the special form of rails, which are to be 12 inches wide, and to contribute steel for a sample mile as a free gift. In this step the United States is an emulator of Spain where steel roads wagon roads have been in operation in Valencia for ten years. They are said to give perfect service. The 12-inch rails, or track plates, will be laid on a special foundation of broken stone. One of the roads is to be built in the heavy trucking district downtown, another in a street of general traffic and a third on a suburban earth road. Steel track wagon roads have been advocated for years by General Roy Stone.

When gasoline is used as a cleanser it will give better service if diluted in water, two quarts of water to a cup of gasoline. Pure gasoline serves merely to loosen the dirt, while the added water will wash away the traces of it.

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Published by Popular Mechanics Co.
Journal Building, - - - Chicago

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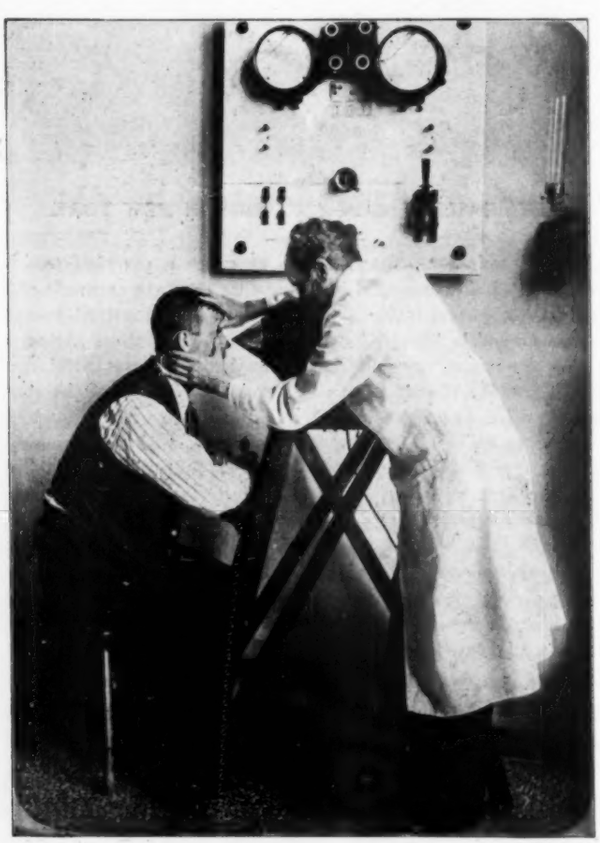
MAGNET DRAWS IRON SPLINTERS FROM THE EYE.

Unique Device Employed by Modern Surgeons in Lieu of the Knife.

Cutting into the eye with knives and probes to remove foreign substances is a practice that is undergoing a decline since the introduction of the large magnet shown in the accompanying illustrations. This machine is a legitimate product of the present mechanical age, when iron splinters that fly thick in the workshops often lodge in the eyes of the workmen and do great injury. The magnet herewith illustrated is the invention of Dr. O. Haab of Zurich, Switzerland. It is now used by many leading surgeons in America. In the operation the point of the magnet is brought close to the eye. The current is opened or closed by the foot, which operates a switch. The metal is first located and then by properly gauging the magnet it slowly moves from the eye until freed, when it flies to the magnet point. The operation, however, requires great skill and practice, as the magnet is a dangerous instrument in the hands of an unskilled surgeon. He may, by improperly directing the instrument, draw the splinter through the delicate parts of the eye and destroy the sight. Dr. Haab in a scientific treatise of the instrument in the Journal of the American Medical Association, the great authority of physicians and surgeons in the United States, says that injuries to the eye from iron splinters are far more prevalent than from any other cause.



Dr. Haab at Work with His Magnet.

Magnet Drawing a Steel Splinter from the Eye.

"In my own circle of observation," he says, "they form three-fourths of all important cases of injury caused by foreign bodies penetrating deeply. Of the whole number of 165 cases in my experience with the magnet, the operation has failed but twenty-three times. It was successful in 141 cases, or in 86 per cent. If we consider the 134 difficult cases in which the splinter penetrated behind the iris and the lens, we find that in these 134 cases the large magnet only failed twenty-three times and was successful in 11 cases, or 83 per cent."

These splinters which could not be removed were so situated in the eye that it was found to be impossible to extract them without destroying the sight.

In 1871 the number of bushels of wheat passing through the Soo canal was 1,376,705, while last year the number of bushels was 60,000,000, or more than forty times as much as in 1871.

Locomotives of the Century

The "Consolidation," built by the Baldwin company from designs and specifications of Alexander J. Mitchell, is shown in Fig. 36. A previous illustration used to designate this engine was incorrect. The engine was built for the Lehigh Valley railroad and locomotives of this type have since been used for heavy traffic in many different parts of the world. Other types of engines that made their appearance from this time until the introduction of the radial stay extended wagon top boiler (Fig. 37) in 1886 have been duly described in previous chapters. This type was designed by William L. Austin of the Baldwin Locomotive Works for the Denver & Rio Grande railroad, although wagon top boilers had been built by Baldwin 30 years prior, when combustion chambers with crown bars were in vogue.

Fig. 36—Baldwin Consolidated—1866.

In 1887 steam as agent of locomotion encountered electricity. Since then many splendid specimens of the electric locomotive have been built; those operating in the Baltimore tunnel of the B. & O. railroad (Fig. 38.) being among the most powerful. The electric locomotive, yet in its infancy, has accomplished much but has not yet earned consideration as a substitute for steam locomotives except where the service is of special nature, such as tunnels, mines, factories and on elevated railroads. An electric locomotive for mine hauling is shown in Fig. 39.

Fig. 37—Locomotive with Extended Wagon Top Boiler.—1886.

AMERICA TO BUILD GREAT NAVY.

By Representative Foss, Chairman of the House Naval Committee.

President Roosevelt has repeatedly declared for a strong navy. I am sure Congress is with the President on this proposition and will do all that is necessary toward building a navy adequate to the needs of the country. I have just returned from New England, where I witnessed the gathering of a magnificent fleet of American warships. They are the best of their kind afloat, and the United States will soon outrank a number of the large powers if we continue to build ships at the rate they are now being constructed and put afloat.

EDISON MORE HOPEFUL THAN BRITISH.

Thomas A. Edison of America seems to take a more hopeful view of the future of electricity than does the Electrical Review of London, England.

The Electrical Review says: "The suggestion of operating long-distance lines by electricity is one which all who have any practical acquaintance with the subject know to be somewhat premature, and the directors of railway companies hesitate to consider electrical schemes for operating any portion of their main lines. With the adoption of electric traction on some of our suburban lines the case is quite different, and within the next two or three years we expect to see electric trains running to Richmond and Wimbledon, and probably as far as Tilbury in connection with the Metropolitan district and Metropolitan Railways.

Fig. 38—Electric Locomotive—Baltimore Tunnel.

"The fact that our American cousins are proposing to adopt the Ganz system on some of their lines does not cause us to alter our opinion in the slightest degree. We have every reason, after the most careful investigation, to be convinced of the soundness of our views, which, although they do not agree with the ideas of some electricians, are those held by all who have had long experience with railways and heavy electrical traction."

Fig. 39—Baldwin Electric Mine Locomotive.

Mr. Edison says: "I believe that within thirty years nearly all railways will discard steam locomotives and adopt electric motors, and that the electric automobile will displace the horse almost entirely. In the present state of science there are no known facts by which anyone could predict any commercial future for aerial navigation."

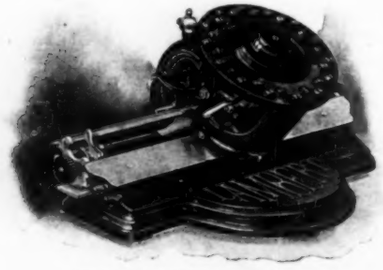
The Street Railway Journal of New York says: "Mr. Edison's, at present, seems a very bold prediction, but it is no more than if fifteen years ago he had said that 95 per cent of the street cars in the country within the same space of time would be in operation by electricity, yet this has come about within half of three decades."

The American Chrysanthemum Association is the latest in trusts. It will combine all the chrysanthemum growers, develop new blossoms, improve the old, and incidentally run up the prices.

NEW TYPEWRITER A MECHANICAL MARVEL.

Science of the Angle Leads to a Simple and Tiny Device That May Mark a New Era in Writing Machine Construction.

Is the principle of the typewriting machine, now generally in use, all wrong? Have inventors of typewriters all along been pursuing a round-about, out-of-the-way course to reach an end to which there is a short-cut at one-tenth the distance? The human hand, aided by mechanics, is the means of writing. Have inventors in their efforts to simplify and expedite this work of the hand devised a mechanical adjunct to the fingers as big and complicated as the time-honored lever typewriter when a machine with one-tenth the amount of mechanical power would have done the work as well or better? Recent developments in the typewriter would tend to proclaim that such is the case; that all along



The Lambert Typewriter.

the typewriter manufacturer has been on the wrong track; that the great nest of slender, susceptible levers, bars connected by wires, pins and hinges, the complicated mass of springs, rods and screws woven together and inclosed in a huge cumbersome metalic frame, are all unnecessary.

It is the appearance on the market of a new and entirely original writing machine that has occasioned this kind of soliloquizing and pondering among many a user of typewriters. This new machine is a tiny device that weighs but five pounds. It is utterly unlike any other typewriter ever made and is constructed on a new and entirely different principle. But this little machine, so simple and unpretentious in appearance, threatens a revolution in the methods of writing. The science of the angle was the guiding spirit of its inventors, while all other typewriters since the earliest machine have followed the principle of the lever. One composite part, keyboard and type-ring moving as one, takes the part of 700 or 1,000 parts in other machines. This reduces the size and weight three-fourths. It prints from the type direct, not through a ribbon. The type is inked by a pad. The keyboard is no keyboard at all—merely a plate. It hangs on a ball and socket joint at its center. Touch a letter; it tilts and prints. That is all there is to it. The type are under the "foot," a finger's length below; it is all one piece. When you touch a letter the foot swings away from the letter you touch and brings that very type to the center, where the printing is done—through the square hole in the shield of the inkpad. The new machine is called the Lambert. If you had types on the tips of your fingers with a machine that would guide the hand so that the types would be changed, all the letters struck in line and properly spaced, you would have a machine like the Lambert. It is merely a simple machine to guide the hand in writing with type. It is so simple that any person can operate it with short practice. It requires practically no skill to do as pretty work on this machine as the adept on the old-style writers. The speed it is capable of making is not yet known, as it has been on the market such a short time that no person has had enough practice on it to determine what its capacity might be with a trained operator. It has often made 100 words and more a minute, however, with a few weeks' practice. The Lambert might be said to be everlasting. There is nothing to it to wear out except that which can be replaced by any person with little trouble. Because of its few parts and simple construction the manufacturers are able to sell it for one-fifth the price of the ordinary typewriter. For appearance of writing the Lambert has no equal. This is because of its wonderful uniformity of touch and perfect alignment. Its delightful simplicity, combined with its remarkable general efficiency, have already made it popular both West and East.

OYSTER OUTPUT OF THE WORLD.

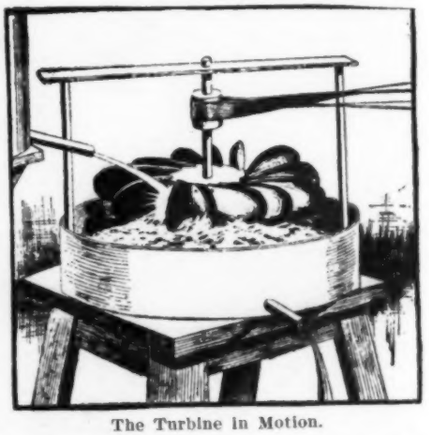
Oysters this season are said to be of better quality than before in years. Statistics compiled with the opening of the season show the enormous proportions to which the oyster industry has grown. The total oyster output of the world is now estimated at 36,000,000 bushels, worth nearly $30,000,000, of this value nearly one-half belongs to the United States. Maryland alone averages an annual output of 11,532,117 bushels, valued at $5,866,126.

JUNIOR ARCHITECTURAL DRAFTSMEN.

A civil service examination for eligibles for positions as junior architectural draftsmen in the office of the supervising architect will be held Oct. 21. From the list of eligibles three or more vacancies will be filled at a salary of $840 per annum. Those desiring to take the examination should apply to the United States Civil Service Commission, Washington, D. C. for forms 304 and 375.

TURBINE OF SHELLS.

To make the pretty turbine shown in this illustration take a large round wooden box without a cover and insert near the bottom a small pipe made of wood or tin



The Turbine in Motion.

to allow the water to flow off. To make the box watertight close all the cracks with putty and cover the inside with thick paint. In the center of the bottom fasten a button having a small cavity to serve as turning point of the turbine's axle. Fasten two small sticks of wood on the opposite points of the box and a broader wooden strip with a hole in its center for the axle connecting their tops as shown in the illustration. Fasten a cork near the upper end of the wooden axle to hold the belt. To make the wheel, take a large round piece of cork or wood, and make teeth-like incisions to hold the shells, which fasten with little screws. After the wheel is done, fasten it to the axle. The water is directed against the shells through a pipe, as shown in the cut.

LONGEST CORN ROW IN THE WORLD.

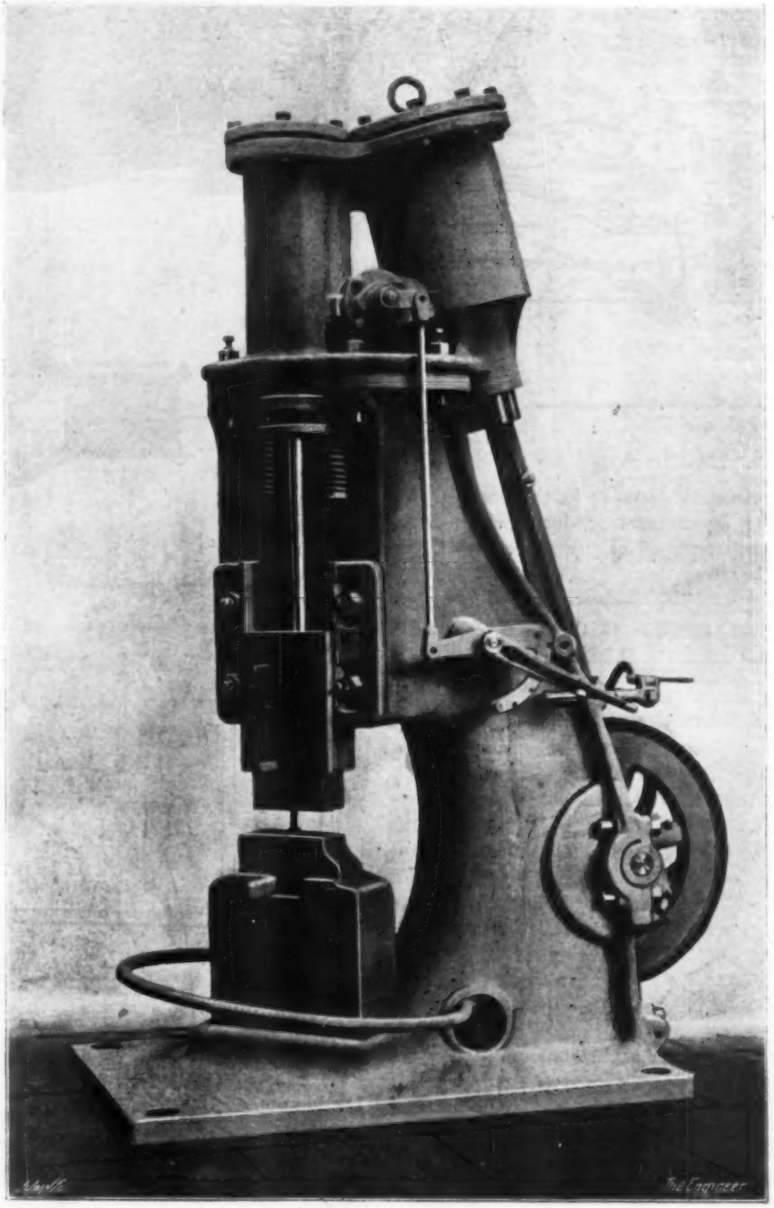
It was supposed that Kansas had run the whole gauntlet of peculiar things, but now she appears with another novelty such as nobody else in all the wide world ever has thought of. A Kingman county, Kansas, farmer is growing a row of corn a little more than 25 miles long for no other reason than to be singular and extraordinary. He commenced in a fifty-acre field and went round and round in a circle with a lister until he had planted the whole in a single row, which commences at one of the edges and terminates in the middle. When he cultivated it, of course, he had to plow the same way. As appearances go the field will make as much crop as if planted in the ordinary way.

To find the horse-power of a boiler, find the square feet of heating surface of the shell, heads and tubes, and divide by 15: the answer will be the nominal horse-power.

COMPRESSED AIR DEVICE MAY SUPPLANT STEAM HAMMER

New Machine that Appeared in England is Attracting Much Attentien

A hammer that is worked by air instead of steam and will do actually as much work, both as to size and speed, as a steam hammer of equal weight, has made its appearance in England and is attracting considerable attention. Light or heavy blows with long or short strokes can be struck at will, the regulation being easy, accurate and instantaneous. The hammer is made by B. and S. Massey of Manchester. It is operated by a double-acting pump placed immediately behind which supplies air in the place of steam at the top and bottom of the hammer cylinder at each stroke. The pulleys and crank are placed low down in order to insure steadiness for the mammer and are of very compact design so that they may be arranged within the standard. The hammer is controlled by a single valve, which is placed between the cylinders, and by varying position of the valve by either hand-lever or foot power the operation of the hammer is promptly and easily regulated by the attendant. When the levers are in their top position, air is forced only under the hammer piston and the tup is held up at the top of its stroke and remains stationary there. On either lever being depressed, the air passes alternately above and below the hammer piston and the hammer begins to work. The further the lever is depressed the heavier the blow until the full blow is given. As soon as the lever is released the tup rises to the top of the stroke and remains there. The tup can be held firmly down on the anvil when it is required to use the hammer as a vice. This is convenient for bending work and holding it during various operations. Compressed Air for August contains a more detailed account of the machine.



Massey Pneumatic Power Hammer.

ELEPHANTS IN A TRAIN WRECK.

Four elephants professionally connected with the well-known circus of, say, Spangles and Sawdust, were journeying over the Northern Pacific in their private car, the other day, when that particular car, in spite of its ballast, jumped the track near Prescott, Wash., and was wrecked. The four attendants were injured, but the elephants escaped unhurt, saving even their trunks, and began quietly cropping grass along the track—a fine example of self-possession for other passengers in a wreck to imitate.

WATER FOR ATLANTIC OCEAN MADE TO FLOW INTO PACIFIC.

The pumping station of the Butte, Mont., water works raises the water 800 feet into a reservoir from which the water flows by gravity through 28 miles of pipes to Butte. The water is taken from a stream flowing into the Gulf of Mexico, carried across the crest of the continent and delivered on the banks of a stream which flows into the Pacific ocean, thus robbing the Atlantic to benefit the Pacific.

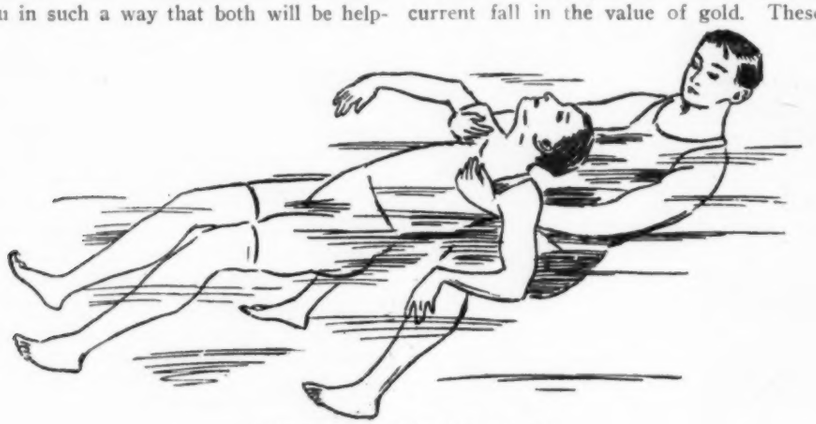
THE DRINKS THAT ARE DANGEROUS.

Alcohol, which has long been the bugbear of previous opponents of the drink habit, is now regarded as a tame and harmless beverage in comparison to many French drinks. The French academy of Medicine has advised the government to prohibit by law the sale of absinthe, anisette, vermouth and Chartreuse, as well as gin and all classes of bitters. Many so called "temperance" drinks and the various "bitters" which are the bases of all cocktails are charged with abounding in serious menaces to health. Chartreuse, long prepared only by a religious brotherhood, is said by the academy to be very poisonous and to contain thirteen ingredients that are dangerous to health. Such an indictment from such a source as France is far more affrighting than anything the temperance people have told us about alcohol.

TO RESCUE A DROWNING PERSON.

Mistaken Idea That He Will Rise Several Times to the Surface.

It is a fallacy to suppose that a drowning person rises several times to the surface of the water. There is no law, says Physical Culture, to determine how often a person rises to the top of the water. So waste not a moment in looking for the third rise, but take off your shoes and heavy clothing, jump into the water and swim for the bubbles as they indicate the air from the lungs of the one under water. If the drowning person struggles, approach from the rear. Otherwise he may catch you in such a way that both will be helpless. Try to turn the drowning one on the back. Take a firm hold of the arms, just above the elbow and draw them up at right angles to the person's body. He will then be under your control and can neither, turn, clutch nor struggle to any effect. Then by employing the back stroke (swimming on the back, using the legs for propulsion) you can easily bring him to land. If his struggles are violent, slip your hands under the armpits and place them upon the chest; then raise the arms at right angles to the body, (keeping the head out of water) turn on your back, using the legs for propulsion, arms being used to support the drowning person, the rescuer's body being undermost.



"You can easily bring him to land."

THE COMING RISE IN PRICES.

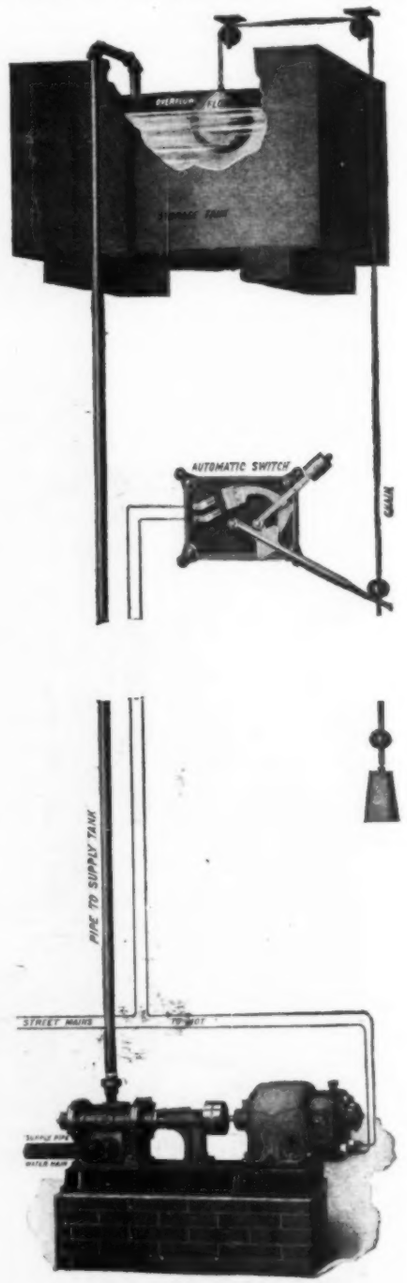
From ore to finished product, nails are produced principally by natural forces acting through machinery and under human supervision. While the amount of human effort consumed in the production of nails will undoubtedly be reduced from time to time, this human effort is now a very small part of the total energy consumed, and it is not probable that the percentage of reduction can equal that for gold, says the Engineering Magazine. With considerable confidence we may therefore say that nails will be higher in price twenty years hence than they are now. What is true of nails is also true of the majority of those staple articles which are now produced principally by automatic machinery. We may say the same thing of the mass of agricultural products, because the element of time in production cannot be reduced to an appreciable extent, and because the reductions obtainable through larger product from a given area and through improved shipping facilities form only a small part of the total cost. We may also find other reasons why the prices of agricultural products will rise. Land, being a natural product, cannot be reduced in cost by improvements in process of production; being strictly limited in supply it will rise in price by reason of increase in demand, even without any concurrent fall in the value of gold. These will cause an increase in the cost of producing agricultural products which probably will fully offset any reduction of cost in other ways.

QUEER COURT DECISIONS IN NEW YORK.

Several very significant decisions have recently been rendered by judges in New York State. One affirmed the right of a wife to open and read her husabnd's letters. Justice Springer of the New York Supreme Court has held that gross extravagance and even forgery committed by a wife to raise money, do not constitute cause for a limited divorce. Another judge justifies a wife in taking snakes to bed with her. Still another decision holds that a husband must put up with a singing servant girl if his wife makes no complaint.

AUTOMATIC ELECTRIC PUMPS.

Electricity enters more and more into the practical every day life. It warms us when we are cold; it makes a delightful breeze just where most needed; it cooks, lights, announces the arrival of our friends and scares burglars away. One of the most serviceable of recent applications is that of pumping water for filling tanks upon the top of residences or factories. The General Electric Co. build a variety of electric pumps, one of the most recent of which is shown in the cut. The motor is placed usually in the basement and takes current from the same supply which lights the house. The motor is direct connected to a screw pump and the range is from 900 to 1,400 revolutions per minute. The small machine weighs complete with pump only 325 pounds and will lift 500 gallons an hour to a height of 100 feet. A larger outfit will raise 1,800 gallons an hour 160 feet, and weighs 1,100 pounds. The apparatus requires absolutely no attention whatever, beyond an occasional oiling. The cut shows the automatic switch which turns on the current and sets the motor at work when the tank is lowered to any determined point, and when filled turns the current off again and the pump stops.



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ASTOR, LENOX AND

Easy Electrical Experiments

By L. P. Dickinson

HOW TO MAKE A LABORATORY STORAGE BATTERY.

The most puzzling question which the amateur electrician has to solve relates to the selection of a battery suitable for general use in experimental work. Bichromate cells are powerful while they last, but they are expensive to maintain and polarize quickly. Other forms of batteries may be purchased, but they are expensive. The ordinary gravity or Daniell cell gives a very constant electromotive force, but on account of its high internal resistance it is not capable of yielding strong currents. Secondary or storage cells are capable of delivering a very strong current and have a very constant electromotive force, but it is necessary to charge them from some other source of electricity. The ideal arrangement would appear to be the use of storage cells in conjunction with gravity cells, the latter being used to charge the former. The present chapter deals with the construction and operation of a small storage cell for the use of amateurs.

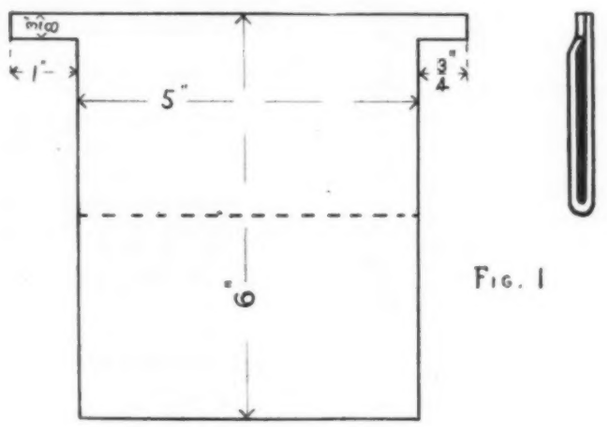


Fig. 1

The cell will consist of three elements, namely, a series of lead plates, a solution of sulphuric acid into which the plates dip, and a jar for holding this solution.

Make a tight wooden box, which is 5⅛ inches long, 4 inches wide and 3 inches deep, measurements being taken on the inside of the box. The material for this box should be ⅝ inch thick, and the box should be put together in the best possible manner so as to be water-tight. It may be advisable to have the box made by a carpenter in order that it may be more efficiently constructed. It should be put together with screws and glue. Then immerse the box in a dish of hot paraffine wax, or beeswax, leaving it there for at least one hour. If only a little wax is available, a shallow pan may be used and one side of the box immersed at a time. But extreme care should be taken to see that the hot wax penetrates to every fibre of the wood and fills up all corners and cracks. This box is to contain the acid, hence the necessity for the careful boiling in the wax.

Next we will make the lead plates for the cell. At a hardware store procure enough sheet lead to make nine plates of the size and shape shown in Fig. 1. After the plates are cut out each one is to be bent double at the point indicated by the dotted line. Before doing this, however, bore each plate as full of ⅛-inch holes as you can without weakening the plate. The plate is then doubled in the middle and has the shape shown at the right in Fig. 1, there being a space of ⅛ inch between the two sides of the bent plate. It may be well to avoid boring holes near the point where the plate is to be bent, to avoid weakening at that point.

Having prepared the lead plates in the manner above described, procure at a paint shop about two pounds of red lead and the same weight of litharge. These are materials used commonly by painters. In a glass dish mix a stiff paste, made by adding sulphuric acid to water in the proportion of 1 part of acid to 20 parts of water, and then adding red lead so as to make a very stiff mixture. Select four of the lead plates and fill the space in the interior of each full of this paste. It will probably be necessary to solder the plate together at the top where the two edges meet.

In the remaining five plates place a paste made up from litharge and sulphuric acid in the manner just described. Then set the plates aside to dry.

After the plates are dry they are to be assembled. Make sixteen wooden strips 3 inches long, ⅛ inch thick and ⅜ inch wide. Boil them thoroughly in melted paraffine wax; also make four pieces ⅜ inch wide, 7-16 inch thick and 3 inches long, paraffined as just described. These are for separating the plates and for holding them in place.

In the next chapter, which will appear October 4th, we will explain how to set up and use the cell.

STEEL CABOOSE FOR USE IN STEEL TRAIN.

Built to Serve With Dump Cars, But Its Field May Be Broadened Until It Is Employed on All Freight Trains.

A steel caboose, built by the Goodwin Car Company, has attracted much attention in Chicago railway circles, and the prediction is made by some that it may supplant the old style caboose on all leading railroads. This car, however, was not intended for regular service. It is to be used in connection with a train of Goodwin dump cars. Thus the entire Goodwin train in this case will be of steel cars. This serves as a great advantage in that different methods have to be employed in the maintenance of the steel cars from those employed in the wooden ones, and now the trainmen will not have to be bothered with the former inconvenience occasioned by having the wooden caboose mixed up with the strong steel train. The steel caboose has so many advantages over the present style car that many believe its field of service will be broadened, with that of other steel cars, until the freight train of the future may consist of all steel cars with a steel caboose behind.

The Steel Caboose.

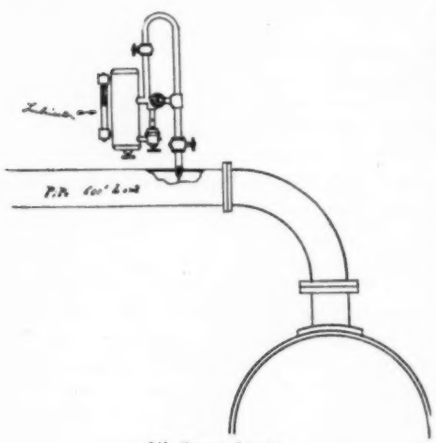
The caboose is provided with a full supply of parts liable to damage and tools for use in case of accident. It is equipped with air reservoir and valve, so that the conductor may dump the train either wholly or in part from the roof of the caboose.

SHOP NOTES

STOPPING LEAKS IN STEAM MAINS.

One of the most annoying troubles to the man in charge of a steam plant is a leaky main. Even though the leak be small, it is always an eye sore and often resists the most persistent efforts made to stop it. The Practical Engineer describes a cure which was effective and so simple, any one can try the experiment with little labor.

The mains in question were 450 feet long, of 16-inch pipe, carrying 100 pounds; and one line of 8-inch pipe 300 feet long, under 125 pounds pressure. Both these mains were continually developing leaks, which were stopped by attaching an ordinary lubricator to the steam main just after it leaves the boiler. The pipe from the lubricator should project about one inch into the main.



Oil Stops Leaks.

The first amount of oil used in the larger main was one-half pint in 24 hours, and in a short time the leakage stopped. After that the amount of oil was reduced to one-half pint in 48 hours. This amount is used right along.

Not only was the introduction of oil found to be of benefit in the matter of stopping the leaks, but it was also found that the pipe was no longer subject to corrosive action of any kind, and a marked difference was at once noted in the ease of the working of the steam traps.

Another feature is that the condensation has also decreased to a marked degree. The stopping of the leaks is caused by the fact that the entire inside surface of the pipe gradually becomes coated with an oleaginous matter which fills up the small crevices upon the inside. To this coating also is due the preservation of the pipe and the decrease in condensation. Almost everyone knows that oil is a very good non-conductor of heat, consequently the film which gathers upon the inside of the pipe acts somewhat in the nature of an inner covering of the most efficient quality. To those engineers having long steam conduity the results promised warrant a trial. It takes but a few minutes to apply the lubricator, and once attached and regulated, it needs no further attention other than refilling the oil chamber of the lubricator.

FITTING CONNECTING-ROD BRASSES.

A correspondent in Steam Engineering gives some excellent suggestions on fitting connecting-rod brasses, and says:

First, to fit new brasses, key them into their strap, separating them by one thickness of russia iron, as at A and B, Fig. 1. Then swing them up on the lathe face plate or boring in the usual way. The pin upon which the brasses are to fit should now be callipered over two thicknesses of russia iron, by inserting under one leg of the calliper a doubled piece of that material. Bore the brasses to this size, remove the russia iron liners, and the brassses are ready for fitting. This oversize boring is for the purpose of giving ample clearance at the sides (C and D, Fig. 2), where no work is done and where close fitting is not necessary. This clearance allows the lubricating oil to gain access to the pin much more readily than would be possible if the brasses were fitted

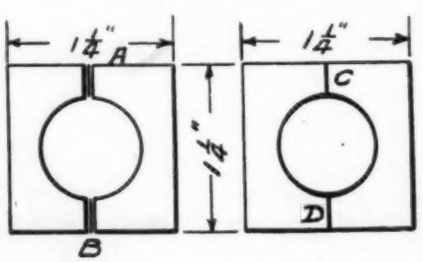


FIG. 1. FIG. 2.

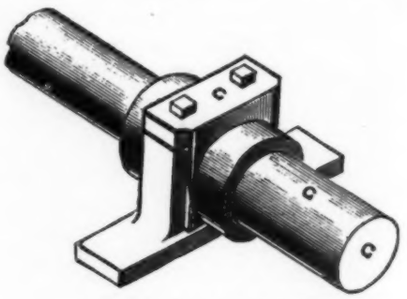
closely all the way around. This boring operation applies to new brasses or to old ones which are planed up together and rebored.

Next, smooth the pin and see that it is round and in good condition. Mix a little marking paste of lampblack and oil. Cover the pin with this paste, spreading it as thinly and evenly as possible, giving just enough to spot the brass. Never fit each brass separately to the pin, as the fitting will change when both are keyed in place in their strap. Place both together onto the pin, keying them into the strap with a piece of wood replacing the butt end of the connecting rod. Key them up just tight enough to allow the strap to be turned around the pin easily, yet without lost motion or "shake." Take the brasses off and scrape in the usual way, repeating the operation until a proper fit is obtained.

Brasses fitted in this way do not have to be worn down to the pin, but will, if properly keyed, run from the start with very little friction.

PROTECTING ENDS OF SHAFTING.

Accidents are frequent from operators in a factory or shop having their clothing catch in a revolving shaft. To protect the end of a shaft which is within reach of workmen, is an easy matter.



CAP COVER FOR SHAFT ENDS.

Exposed shaft ends should be covered by a metal cap, as shown in the cut. The cap should fit to shaft closely enough to revolve with it, but loosely enough to stop when clothing is caught by it. Such caps may be easily made of tin or any sheet metal and no special skill is needed for their construction.

A FOOL EXPERIENCE.

An accident occurred recently which well illustrates the wisdom of the old saying that "five minutes of earnest thought are worth more than an hour's hard work." One of the front wheel steering knuckles of an automobile broke off short, next to the hub, says the Motor Age.

The operator knowing that he could readily get a new steering knuckle in stock at a certain supply house, took out his monkey wrench and proceeded to loosen the lock nut which kept the hub in place on the spindle of the steering knuckle. Unfortunately for him he did not take advantage of the old saying quoted above, and failed in the attempt. Thinking that his wrench was not sufficiently large, he called for the services of a blacksmith who advanced to the fray, armed with a monkey wrench at least 2 feet long and of gigantic proportions. At least 55 minutes were spent fruitlessly and then it was decided to impress an express wagon into service and take the wheel to a repair shop. After getting it there the foreman was informed that he had an awful job on his hands but smilingly told the owner that it would only take a few minutes. A bet was accordingly made on the result. Whether it was paid or not is not a matter of history. The foreman called one of his men and said: "Jim, I will give you just

5 minutes to get that spindle out of the hub." The job was accomplished in 50 seconds and thereby hangs a tale. It was a left hand thread.

JUDGING QUALITY OF SOLDER.

Common solder contains weights of lead and tin; fine solder contains two parts of tin and one of lead; coarse solder two parts of lead and one of tin. In solder the proportions of metal can be judged from the appearance of the alloy, says Mining and Scientific Press.

When it contains a little more than one-third of its weight of tin, its surface, on cooling, exhibits circular spots due to a partial separation of the metals, but these disappear when the aloy contains two-thirds of its weight of tin. These alloys melt at a much lower temperature than of their constituent metals. Common solder melts at about 240 deg. Centigrade, and fine solder at 180 deg. C., while the melting point of tin is 232 deg. C., and that of lead 327 deg. C. Soldering is not entirely a mechanical adhesion, depending, partly, on the formation of an alloy between the solder and the surface of the metal to be soldered. This makes it absolutely necessary that the surfaces to be united by the intervention of solder shall be perfectly bright and free from oxide. Several substances are employed to insure this at the moment of applying the solder; one of the commonest is muriatic (hydrochloric) acid, "killed" with zinc; that is, in which a lump of zinc has been dissolved to form a chloride of zinc which melts over the surface of the work, dissolving any oxide and protecting the metal from the oxidizing action of the air. Sal-ammoniac, or sal-ammoniac and chloride of zinc, are sometimes used. Resin in powder is often sprinkled over the metal to be soldered, when the heat melts it and forms a varnish to protect the metal's surface from the oxygen of the air.

BOLTING CLOTH PINCHERS.

The accompanying drawing shows a pair of pinchers used in mill for stretching

bolting cloth for reels, says a writer in American Miller.

I had these made at a blacksmith shop from tool steel. The jaw, A, is straight and should be about two inches long, while the other jaw should be curved the same as in ordinary pinchers. This jaw having about four teeth and coming up tight against jaw A, holds the cloth from slipping. The ends of handles serve as a tack-puller and screw-driver.

SPRING DIVIDERS FOR SMALL CIRCLES.

A pair of small spring dividers which will describe a circle 1-64 of an inch in diameter, is explained in the American Machinist. The tool can be made from the following details: The piece A is made of sheet steel .040 inch thick; it passes through the slot down in B and is a good, snug fit. The slot is filed out perfectly parallel because the fit at this point is the

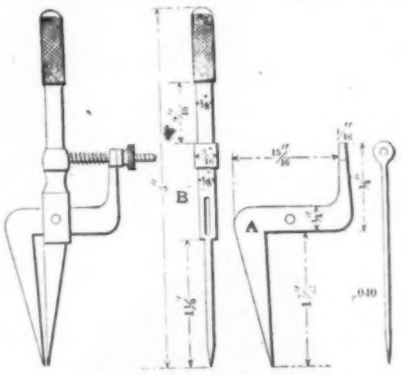


FIG. 1 *American Machinist* FIG. 2

SPRING DIVIDERS.

most important part of the whole tool. The piece A is flattened at the top for an eye through which passes the adjusting screw, which is 2 x 48. The end of this screw is a loose fit in B and is held in place by the pin. These dividers will make a circle from 1-64 to 5-16 inch radius, but they were made especially for small circles, as they are very rigid and can always be depended on for making a single line, which is more than can be said of the majority of small dividers.

COMPARING WEIGHT OF WATER.

One gallon of fresh water weighs 8 1-3 pounds. One cubic foot of water contains 7.4805 gallons and weights 62.37907 pounds. For convenience of computation, a cubic foot of water contains 7½ gallons and its weight is taken at 1,000 ounces, or 62½ pounds avoirdupois. Two hundred and forty galons of water weigh one ton of 2,000 pounds and measures 32 cubic feet. The water (240 gallons weighing one ton) would fill a cube measuring 3 feet 2 inches for each of its three dimensions.

WHEN FUEL OIL IS ECONOMICAL.

"Things in the steam engineering world seem to go in schools, like mackerel," writes F. L. Johnson in September Power. "Now fuel oil is all the rage. Oil is certainly a nice fuel, properly burned, but it must be delivered at the seaboard boiler-rooms for 2 cents, or less, per gallon to compete with coal. From a number of published tests of oil fuel, I find the average evaporation per pound of oil from and at 212 degrees to be 14.25. Not less than 4 per cent of the evaporation of the boiler is used to operate the burner. This leaves a net evaporation of 13.68. Repeated tests have shown that good coal will evaporate 10½ pounds of water from and at 212 degrees per pound.

Suppose the market price of good coal to be $4 per ton, which it is not by the cargo, and oil to be 2 cents per gallon. One cent's worth of coal will evaporate 52½ pounds of water, and one cent's worth of oil will evaporate 52 1-3 pounds. At the prices named the fuel values are nearly equal. It strikes me that the oil furnaces are not so efficient as they should be. With a theoretical value of 20 pounds of water evaporated per pound of oil, only 13.68 is realized, or 68 per cent. With good coal an efficiency of 70 per cent is obtained by hand firing, and by some stoker advocates even more is claimed. I have visited a great many oil refineries, but have in none of them seen oil used for fuel. Since the Columbian Exposition, I have looked for oil-fuel, but it seems that the Standard Oil Company can hardly indulge in that luxury.

The average fireman will not attend to liquid fuel fires any better than he will to coal fires, and in most instances not so well. It is a matter of fact that they need better attention. I have seen smoke so black and thick pouring from a liquid fuel fire that ordinary coal smoke looked light colored in comparison.

CORRESPONDENCE.

G. F. A.—Send us your street address; can put you in touch with desirable parties to assist you in your invention.

AURORA N. Y.—We are in receipt of a sealed envelope from Aurora, N. Y., with no inclosure.

A London weekly paper recently unearthed a quaint army order. It deals with the machine guns provided for certain volunteer corps, and advises that, where possible, "mules should be employed to draw them.' "When a mule is not available, however," it goes on, "any intelligent non-commissioned officer will do instead." —The Japan Weekly Mail.

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The daily coal production of the United States, amounting to an average of over three-fourths of a million long tons, if loaded into cars, would form a continuous train about 250 miles in length.

MAGNETIC SEPARATORS IN FLOUR MILLS.

The magnetic separator is considered as necessary a piece of the equipment of a modern flour mill as the rolls or other vital part of apparatus. They were first used in England, and first adopted in this country in 1878. That was the year when farmers began binding with wire; 25,000 wire binders being sold the first season. The American Miller gives an interesting bit of history on the subject as follows:

Here is where the matter affected millers: The wire rusted if it became damp, easily broke, and bits of wire inevitably got into the wheat through the thrasher. These little pieces of wire could not be taken out by the separating machinery, which did, however, take out the longer pieces, and went to the millstones. The

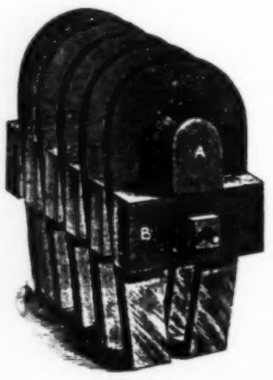

Fig. 1.

action of the millstones flattened them out and made them more or less like diminutive saws.

Then the damage commenced. The chop went to the bolts and these saws cut their way through the cloth, ruining it, and lodging themselves in the flour. Besides this, the bits of wire would be found lodged everywhere in the mill from separator to packer.

In some localities where the wire binders held full sway millers became desperate. Millers' conventions resolved against the binder, and some millers would not buy wheat that had been harvested with a wire binder—if they knew it. But this was practically impossible to determine, as the bits of wire could hardly be detected in the wheat. And so there was a state of things. The wire binder had evidently come to stay, for a while at least and millers simply did not know what to do.

At this juncture, a gentleman connected with one of the binder companies, Mr. Ransom, came forward with a suggestion which arrested attention. Whether original or not, we do not know; but his suggestion was that magnets placed in any spout through which the wheat passed before reaching the stones would take the wire out. He showed a gang of magnets, bolted together, as shown in the first cut, A and B, showing the blocks of wood used for the purpose.

He became quite a missionary of the idea and a small machine was constructed to show that the magnets would remove the wire. The suggestion took immediate-

Fig. 2.

ly. Millers placed magnets in the grain spouts in all imaginable ways. Fig. 2 shows the form adopted in the Humboldt Mill at Minneapolis. It was considered convenient because the top board being sawed each set of magnets could be lifted out and cleaned, leaving the others to catch the vagrant wire in the meantime.

But what a surprise awaited the miller when the magnets were first put in. Of course, he knew that assorted bric-a-brac could be found in almost any load of wheat; but he was hardly prepared to find how much metal besides the wire binder bits had been going over his machinery, as the magnets demonstrated. It was a revelation and fixed the status of the magnet as a part of the mill's equipment.

MILLIONS FROM COTTON SEED.

Only a few years ago cotton seed was regarded a nuisance outlawed by the states of the cotton belt. In the Mississippi laws of 1857 was one imposing a fine of $20 for every day that cotton seed was left around a gin house to menace public health. In 1870 a process for extracting oil from cotton seed had been discovered and a product worth $14,000 was realized. What was deemed a nuisance in 1857 continued to prove valuable through invention until the census year of 1900 it gave a return to the mill operators of more than $42,411,000. Cotton seed oil is used on the table rivaling that of the olive and threatening to drive the latter from the market. The oil enters into soap and butter making and is burned in miners' lamps The hulls are used in making paper, fuel, feed and fertilizer, while enormous quantities of the seed itself find a market as food for cattle.

Since W. K. Vanderbilt's announcement that he had sold his automobiles and given up automobiling the popular diversion has undergone a noticeable decline in New York.

M. Heirmann, a Belgian engineer, has demonstrated that in automobile service there is less tendency for the cylinder in a gas engine to wear oval when working in a horizontal position than in a vertical motor.

COATING FOR CAST IRON PIPES.

A promising field for experiment will be found in devising a more practical and lasting coating for cast iron pipes than is known at present. Hundreds of thousands of tons of cast iron pipe are laid each year, and gas and water companies would hail with joy some suitable process and material for coating these pipes so as to preserve them from the chemical action which commences the moment the trench is filled in. This deteriation of the pipe is of course greater in some localaties than in others, depending on the formation of the soil. The interior of the pipes as a rule does not suffer. The constant flow of water in a water main does not permit of sediment remaining long in one spot, and the oils and tar which condense in gas mains are excellent preservatives.

Apparently but little progress has been made in preserving pipes during the last 30 years. As early as 1848 an Englishman, Dr. Robert Smith patented a process for using linseed oil in tar as a coating. However plain tar seems to be the substance in most general use, and the method of application is to heat the pipe to 300 degrees or more and immerse it while hot in a tank of the tar. But tar varies greatly, running like molasses in summer and becoming hard and brittle in winter. Also its age makes a great difference. Some manufacturers use one barrel of dead oil of tar to 7 barrels of tar.

Experiments may easily be made at home in a large kettle, using small fragments of cast iron pipe for the dippings. The pipe foundries of the country would gladly make the man rich who can discover a better and more lasting method than that now emloyed. The process however must be inexpensive and the material fairly cheap.

SIMPLE DEVELOPING TROUGH FOR FILMS.

A new developing trough, which is meeting with much favor in England, is a simple type that might be constructed by any American tinsmith for amateur photographers. The trough is called the "Tyma," and is intended for rollable film. The roll or film A revolves on a spindle at one end of the trough. The black paper covering B, is carried out through a slit at one end and, as it is pulled out the film, C, falls down in loops into the developer. The developer is said to have free access to all portions of the film and the looping is so that the sensitive surface does not come in contact with the celluloid backing and the surfaces do not cling together. The device seems to require a large amount of developer for one film but it is said that the much diluted developer for time development is cheaper than the ordinary tray development, and that more even results are obtained with varied exposures. When the development is complete the developer is poured off and water poured in. This is followed by the hypo and again by water, by placing the trough under the tap and allowing the water to run in through the funnel. Thus the development, fixing and washing is all completed without once handling the film.

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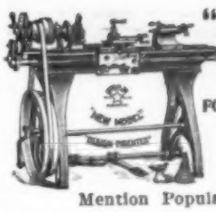

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